REVERSE MODELING OF CAR DOOR USING LASER SCANNING METHODOLOGY

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Report submitted in fulfilment of the requirements
for the award of the degree of
Bachelor of Mechanical Engineering with Automotive Engineering

Faculty of Mechanical Engineering
UNIVERSITI MALAYSIA PAHANG

DECEMBER 2010

SUPERVISOR'S DECLARATION

We hereby declare that we have checked this project and in my opinion, this project is adequate in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering with Automotive Engineering.

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STUDENT'S DECLARATION

I hereby declare that the work in this project is my own except for quotations and summaries which have been duly acknowledged. The project has not been accepted for any degree and is not concurently submitted for award of other degree.

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ACKNOWLEDGEMENTS

I would like to express my gratefulness to Allah S.W.T for giving me strength and wisdom to finish in my project. I also want to express my sincere gratitude and supervisor, Professor Dr. Rosli Abu Bakar for his constant guidance and motivation. My endless appreciation to Mr Gan Leong Ming as my co supervisor in constructive idea and lead me to accomplish this project. To all panel for presentation one and two that gave me much of advise and space for improvement, thank you to all of you.

In preparing this thesis, I was in contact with many people especially three teaching engineer of the Mechanical Laboratory, especially to Mr Muhammad Imran Sairaji, Mr Faizul Shahidan Rajuli and Mr Mahdhir Mohd Yusof. They all have contributed to my understanding and valuable thoughts during progress of my project.

I am gratefully expressing my thanks to my whole family who understand and gave me the spirit also continuing support to finish this project. Last but not least, I am grateful to my fellow collogues who has offered their help, assistance and their moral support direct and indirectly. May Allah bless of you.

ABSTRACT

Reverse engineering was not commonly knew by other people and mainly employed for shape design applications. By use of this method, under developed countries can decreasing the technologic gap between itself and industrial countries. 3D scanner is one of the tools in the reverse engineering. The recent advancement of 3D non-contact laser scanners enables fast measurement of parts by generating a huge amount of coordinate data for a large surface area in a short time. Although the scanning process itself is not new, the processing power requirements of the captured cloud data is enormous, and only now, with the development and affordability of high powered computers, can the software be used effectively and efficiently. Complied with the demanding of the environment in the industry, each company will arrange the strategy in increase their quality. One of the alternatives that can be developing to improve the quality is research in the curvature surface. So, the objectives of the project are to scan and gather 3D point's clouds of car door and to generate and analyze the quality of car door 3D model. Firstly the door panel needs to be uninstalling from the car body to make the scanning process become easier. Then the surface of the door is altered because the scanner is using reflection concept. A density of a material can be determined by the reflection also act as the medium to get the true image for an object. Lastly, start scanning and then edit the scanned product using Polywork software as a way to condition the result obtained. Thus a lot of quality improvement can be developing in any sector by using the data of the 3D model such as important in study of safety.

ABSTRAK

Kebiasaannya kejuruteraan unduran masih lagi kurang diketahui oleh orang lain dan ia terutamanya digunakan untuk membentuk aplikasi rekabentuk. Dengan menggunakan cara ini, negara-negara maju dapat mengurangkan jurang teknologi antara mereka dan negara industri. Imbasan 3D adalah salah satu daripada alatan kejuruteraan unduran. Kemajuan terkini pengimbas lazer 3D bukan jentera membolehkan ukuran cepat untuk bahagian-bahagian dengan mewujudkan jumlah yang sangat besar untuk data setara untuk kawasan yang luas dalam masa yang singkat. Walaupun proses imbasan ini bukan baru, keperluan kuasa proses untuk rangkuman adalah besar,dan hanya dengan kemajuan dan kemampuan komputer berkuasa tinggi, membolehkan perisian itu digunakan secara efektif dan efisyen. Dengan mematuhi permintaan industri, setiap syarikat akan menyusun strategi dalam meningkatkan kualiti. Satu daripada alternatif yang boleh dimajukan untuk meningkatkan kualiti ialah kajian dalam permukaan lengkung. Oleh itu objektif projek ini ialah untuk imbas dan kumpul rangkuman titik 3D dari pintu kereta dan untuk menghasilkan model 3D pintu kereta. Permulaannya, pintu ditanggalkan daripada kereta untuk memudahkan proses imbasan. Kemudian, permukaan pintu dikemas kerana pengimbas itu menggunakan konsep pantulan. Ketumpatan, sesuatu bahan boleh ditentukan oleh pantulan yang juga .berperanan sebagai medium untuk mendapatkan imej sebenar untuk sesuatu objek. Akhirnya, imbasan dimulakan dan kemudian hasilan imbasan disunting menggunakan perisian Polywork sebagai langkah untuk memperelokkan hasil yang diperolehi. Oleh itu, banyak peningkatan kualiti dapat dimajukan dalam pelbagai sektor dengan menggunakan data daripada model 3D yang mana penting contohnyer di dalam pengajian keselamatan.

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CHAPTER 1

INTRODUCTION

1.1 REVERSE ENGINEERING

At the beginning reverse engineering was not commonly knew by other people and mainly employed for shape design applications. Right now the situation is become quite different, showing a wide spread of possible other applications like medical and archaeological. But unfortunately while the work done in the mechanical shape design has created a certain level of expertise, that right now could help the digitizing operators in the right acquisition system choice and working parameters setting, these new working fields are graved by a certain number of questions and problems that come from the inexperience, for the first time approaching this technology.

By use of this method, under developed countries can decreasing the technologic gap between itself and industrial countries, but use of this method must be responsible to requirements and has development and application affect and performs innovation in these countries. The most important advantages and applications of reverse engineering are as follow (Radfar and Khamseh, 2006):

(i) The primary benefit of reverse engineering is new product development.
(ii) Transforming absolute products into useful ones by adopting them to new systems and platforms.

(iii) The primary objective of reverse engineering is the development of unrestricted technical data, adequate for competitive procurement, through engineering evaluations of existing hardware.

One of the tools in the reverse engineering is 3D scanner. The recent advancement of 3D non-contact laser scanners enables fast measurement of parts by generating a huge amount of coordinate data for a large surface area in a short time. In contrast, traditional tactile probes in the coordinate measurement machines can generate more accurate coordinate data points at a much slower pace. Therefore, the combination of laser scanners and touch probes can potentially lead to more accurate, faster, and denser measurements.

1.2 PROBLEM STATEMENT

Advanced 3D Laser Scanning processes have developed over the last decade and are now available and affordable for medium to large companies as well as education. Although the scanning process itself is not new, the processing power requirements of the captured cloud data is enormous, and only now, with the development and affordability of high powered computers, can the software be used effectively and efficiently. In virtually all applications, a 3D laser scanner will improve speed and accuracy thereby improving productivity (Ertu et al, 2006). This has led to an increase in the potential of 3D modeling and animation via cloud data capture.

Complied with the demanding of the environment in the industry, each company will arrange the strategy in increase their quality. One of the alternatives that can be developing to improve the quality is research in the curvature surface. However the ability to integrate 3D scan data with 3D software and technology now gives users in all design fields the potential to construct complex organic shapes, which may only possible when using advanced 3D surface modeling software in the past. There are many difficulties in modeling 3D shapes for use in design work. Thus it need to be overcome because importance for communication between engineer, vendor and the production itself.

The data can be used to make major improvement for the quality and also it can become the long distance of quality guarantee for each product. In addition the data also can be use to make improvement on the safety and weight reduction for the part. According to the condition the importance of the data will be interpret at one of the part at the body car which is door panel. Because of that, this study is to develop the significance techniques of scanning a car door as one of the dimensional control component for cars, where is must be able to install for all same model car.

1.3 OBJECTIVES

(i) To scan and gather 3D points clouds of car door.
(ii) To generate and analyze the quality of car door 3D model.

1.4 SCOPES OF PROJECT

There are seven scopes of project to do this project. The scopes are

(i) Literature review on 3D scanning technology.
(ii) Car door surface preparation.
(iii) 3D scanner system setup.
(iv) Acquiring 3D point clouds model.
(v) Transformation to surface model.
(vi) Development of 3D model and surface quality.
(vii) Final report preparation.

Figure 1.1 shows the flow chart resemble the divisions of works and study have been made in all the way of achieve the objective of the project.

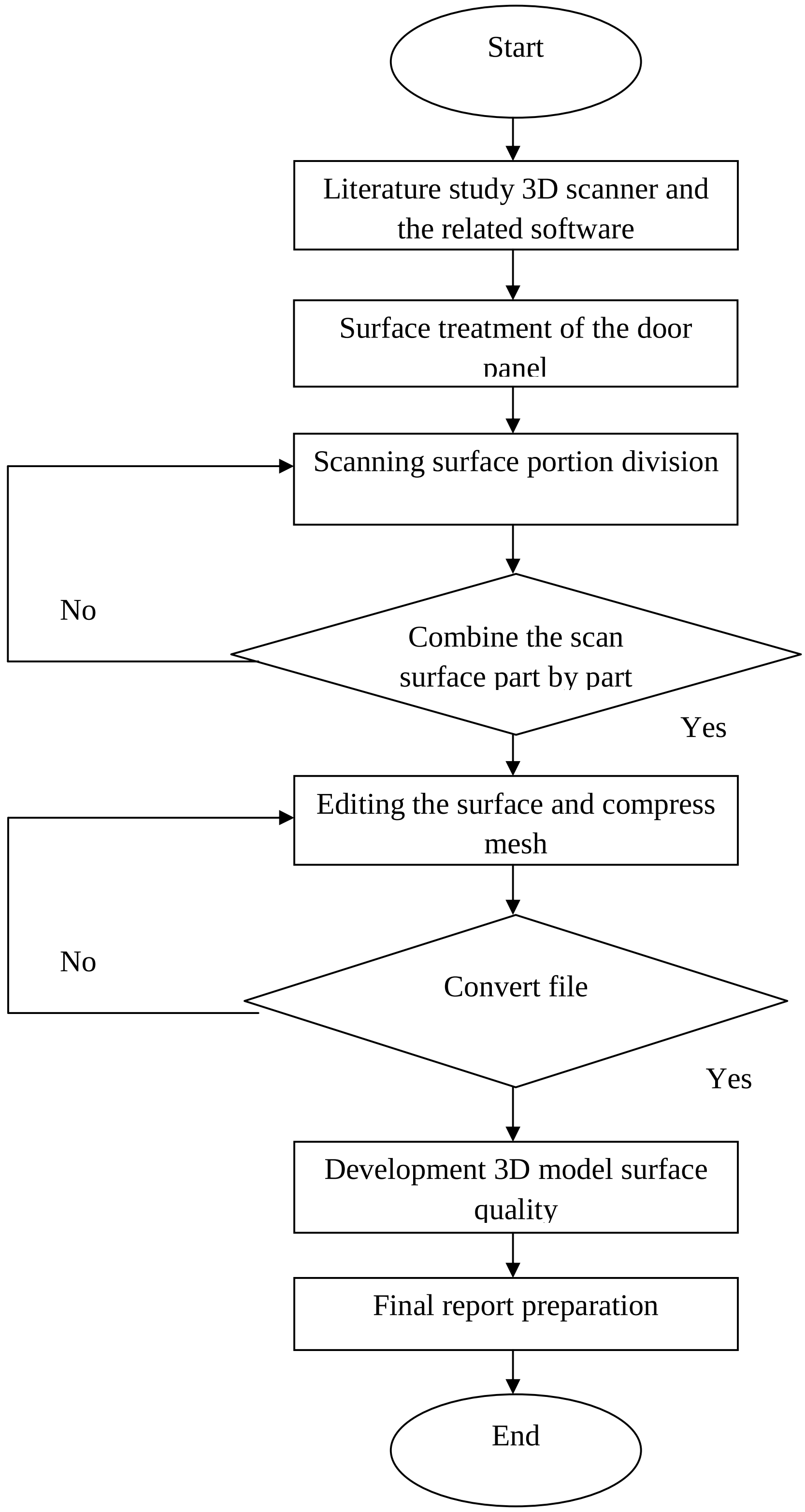


Figure 1.1: The division of work and study

However to complete this project must have proper planning time to ensure it works accordingly in schedule. This can avoid this project out of schedule because of constraint time. The planning of time was prepared in Gantt chart. Both of final year projects 1 and 2 Gantt chart is attached at appendix A and B.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Rapid development of 3D sensing technology has led to the growing use of massive point data in product development, such as reverse engineering, rapid prototyping, manufacturing, and metrology. Such wide use of massive point data necessitates the research on direct processing of massive point data into suitable geometric models that can be used in downstream product design, analysis, and manufacturing. Existing approaches to path generation from massive point data face a dilemma better quality curvature adaptive paths but with painstaking computer-aided design CAD model reconstruction or easy direct path generation but without guarantee on accuracy or efficiency.(Dongdong et al,2009)

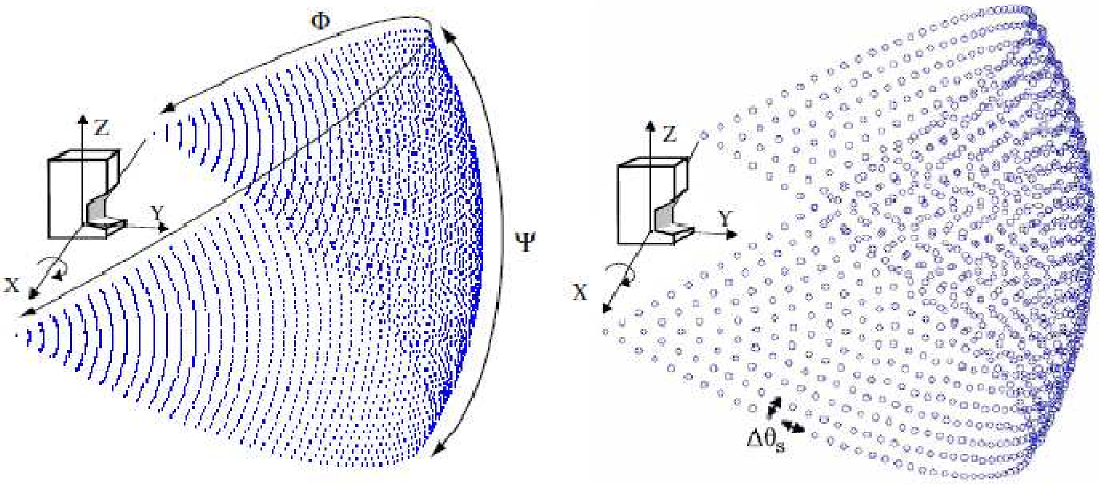
2.2 TYPES OF 3D SCANNER

A 3D scanner is a device that analyzes a real-world object or environment to collect data on its shape and possibly its appearance (i.e. color). Common applications of this technology include industrial design, orthotics and prosthetics, reverse engineering and prototyping, quality control/inspection and documentation of cultural artifacts.Many different technologies can be used to build these 3D scanning devices; each technology comes with its own limitations, advantages and costs. It should be remembered that many limitations in the kind of objects that can be digitized are still present: for example optical technologies encounter many difficulties with shiny, mirroring or transparent objects.

The purpose of a 3D scanner is usually to create a point cloud of geometric samples on the surface of the subject. These points can then be used to extrapolate the shape of the subject (a process called reconstruction). If color information is collected at each point, then the colors on the surface of the subject can also be determined. The “picture” produced by a 3D scanner describes the distance to a surface at each point in the picture. If a spherical coordinate system is defined in which the scanner is the origin and the vector out from the front of the scanner is $\varphi=0$ and $\theta=0$, then each point in the picture is associated with a φ and θ. Together with distance, which corresponds to the r component, these spherical coordinates fully describe the three dimensional position of each point in the picture, in a local coordinate system relative to the scanner.

For most situations, a single scan will not produce a complete model of the subject. Multiple scans, even hundreds, from many different directions are usually required to obtain information about all sides of the subject. These scans have to be brought in a common reference system, a process that is usually called alignment or registration, and then merged to create a complete model. This whole process, going from the single range map to the whole model, is usually known as the 3D scanning pipeline.

According to the Mandow et al (2009), two scanning procedures are usually employed for 3D data acquisition. First, a 2D laser device can be displaced either by an automated system, for object modeling or by a vehicle, for urban modeling. Second, ranges can be obtained from a fixed pose by composition of two rotations of the laser beam, which renders spherical coordinates. With spherical scanners as showed in Figure 2.1 , commonly found in mobile robotics, certain scene regions are scanned with a higher density, which can distort the registration optimization process. Registration is an optimization problem that searches for the spatial transformation of a source range image that produces maximum overlap with a destination scan.



(a) (b)

Figure 2.1: Measure direction density for (a) raw scan and (b) spherical point subsampling

Source: Mandour et al (2009)

The classification of this technology can be divided into two types which are contact and non-contact 3D scanners. However, for non-contact 3D scanners can be further divided into two main categories, active scanners and passive scanners.

2.2.1 Contact 3D scanner

Contact 3D scanners probe the subject through physical touch. A CMM (coordinate measuring machine) is an example of a contact 3D scanner as showed in Figure 2.2. It is used mostly in manufacturing and can be very precise. The disadvantage of CMMs though, is that it requires contact with the object being scanned. Thus, the act of scanning the object might modify or damage it. This fact is very significant when scanning delicate or valuable objects such as historical artifacts. The other disadvantage of CMMs is that they are relatively slow compared to the other scanning methods. Physically moving the arm that the probe is mounted on can be very slow and the fastest CMMs can only operate on a few hundred hertz. In contrast, an optical system like a laser scanner can operate from 10 to 500 kHz.

The touch probes can only generate coordinate points approximately at the speed of 60 points per minute with accuracy ranging from hundreds of nanometers to several micrometers. Although faster analog probes are also available, it’s still much slower than optical area sensors. However, due to the contact mode and the small probe size of tactile sensing, touch probes are not sensitive to surface reflection conditions and able to produce more reliable results on the high curvature areas. Therefore, due to the complementary characteristics of area laser scanners and point touch probes in sensing speed, coverage, accuracy, accessibility, surface conditions, and surface geometry, the integration of a laser scanner with a touch probe can potentially dramatically improve the ways that parts are currently measured. An integrated multisensory coordinate measurement system can benefit in measurement accuracy from touch probes, in measurement speed from area laser sensors, and in part versatility from the availability of multiple sensors.

Figure 2.2: Coordinate measuring machine

Source: www.google.com

2.2.2 Non Contact Active

Active scanners emit some kind of radiation or light and detect its reflection in order to probe an object or environment. Possible types of emissions used include light, ultrasound or x-ray. The types of this category can be determine into seven type which are

Time of flight

The time-of-flight 3D laser scanner is an active scanner that uses laser light to probe the subject. At the heart of this type of scanner is a time-of-flight laser rangefinder. The laser rangefinder finds the distance of a surface by timing the round-trip time of a pulse of light. A laser is used to emit a pulse of light and the amount of time before the reflected light is seen by a detector is timed. Since the speed of light c is a known, the round-trip time determines the travel distance of the light, which is twice the distance between the scanner and the surface.

The accuracy of a time-of-flight 3D laser scanner depends on how precisely we can measure the t time: 3.3 picoseconds (approx.) is the time taken for light to travel 1 millimeter. The laser rangefinder only detects the distance of one point in its direction of view. Thus, the scanner scans its entire field of view one point at a time by changing the range finder's direction of view to scan different points. The view direction of the laser rangefinder can be changed either by rotating the range finder itself, or by using a system of rotating mirrors. The latter method is commonly used because mirrors are much lighter and can thus be rotated much faster and with greater accuracy. Typical time-of-flight 3D laser scanners can measure the distance of 10,000~100,000 points every second.

Figure 2.3: Example of 3D scanner using time of flight

Source: www.google.com

Triangulation

The triangulation 3D laser scanner is also an active scanner that uses laser light to probe the environment. With respect to time-of-flight 3D laser scanner the triangulation laser shines a laser on the subject and exploits a camera to look for the location of the laser dot as showed in Figure 2.4. Depending on how far away the laser strikes a surface, the laser dot appears at different places in the camera's field of view. This technique is called triangulation because the laser dot, the camera and the laser emitter form a triangle. The length of one side of the triangle, the distance between the camera and the laser emitter is known. The angle of the laser emitter corner is also known. The angle of the camera corner can be determined by looking at the location of the laser dot in the camera's field of view. These three pieces of information fully determine the shape and size of the triangle and gives the location of the laser dot corner of the triangle. In most cases a laser stripe, instead of a single laser dot, is swept across the object to speed up the acquisition process.